**This section is excerpted from "Experimental Design for Advanced Science Projects", found at http://www.sciencebuddies.com. You can find this handout in full in your binder.**

## Understanding How Other Scientists in Your Field Design Their Experiments

The best way to get a handle on what your experiments are likely to entail is to look at papers in your area of science and see *what* other investigators are measuring and *how.* You should take note of things like:

- What variables they are investigating
- Which are the independent variables and which are the dependent variables.
- What their sample size is, meaning how many observations they make
- What controls they use
- How many experimental replicates they have

Once you have an idea what the standards are in your field, you can begin designing your own experiments, taking into account variables, controls, and how to maximize your ability to see the effect of a particular variable.

## Understanding the Different Types of Variables

There are two types of variables: quantitative and qualitative. Depending on your experiment, either of these types of variables may be an independent or dependent variable. It is important to recognize which type(s) of variables you are evaluating, as some calculations and statistical tests can only be performed on data containing one or the other type of variable.

**Quantitative variables** are ones that differ in *magnitude.* They can easily be measured and recorded as a number. Examples of quantitative variables include age, height, time, and weight. Quantitative variables are easy to summarize using numerical calculations like median and average.

**Qualitative variables**, sometimes referred to as *categorical variables,* are ones where the observations differ in *kind.* Qualitative variables can be placed in categories like gender (male vs. female) or marital status (unmarried, married, divorced, widowed). This makes them particularly good for summarizing as percentages in a pie or bar chart.

Sometimes, qualitative data can be ranked. For example, a fruit survey might rank the taste of the fruit as:

1 = Very sweet
2 = Moderately sweet
3 = Slightly sweet
4 = Neither detectably sweet nor sour
5 = Slightly sour
6 = Moderately sour
7 = Very sour

Ranked qualitative variables are often called *ordinal variables.* Although the observations are qualitative, the ranking allows some numerical calculations, like averages, to be made. This can be particularly important at times when you want to compare how different people categorize data before and after an event. For instance, evaluating people's mean change in opinion for "How do you think this fruit tastes?" *before* they actually taste the fruit and *after* they get to try a sample. Ordinal variables are particularly common in social and behavioral studies.

In some circumstances, it is possible to choose whether you want to collect quantitative or qualitative data. For example, you can either ask people their exact age (quantitative) or have them select whether they are a child, teenager, adult, or senior citizen (qualitative). By pre-planning your data-analysis methods, you can choose the type of data and thus, the experimental design that is most appropriate for your research goals. When planning your experiments, try consulting Table 1, below, which gives an outline of several different types of variables, examples of data that fits them, and some of the common statistical summaries used with each type of variable.

**Table 1.** This table includes examples of when and how to use the four most common types of variables.

| **Quantitative Variables** | | | |
|---|---|---|---|
| **Type of Variable** | **Definition** | **Examples of Data** | **Common Statistical Tests and Summaries** |
| Discrete | The data are described numerically on a finite scale. There is a logical limit to the precision. | • Number of children in a family<br>• Bacterial colonies on a plate<br>• Coin toss<br>• Shoe sizes | • Mean<br>• Median<br>• Mode<br>• Chi-squared<br>• Standard deviation<br>• Standard error of the mean<br>• Regression<br>• Correlation |
| Continuous | The data are described numerically on a continuous scale that can be broken up into infinite measurements. Theoretically, there is no limit to the precision. | • Temperature<br>• Age<br>• Weight<br>• Time<br>• Length | • Mean<br>• Median<br>• Standard deviation<br>• Standard error of the mean<br>• Regression<br>• Correlation<br><br>SEE NEXT PAGE FOR QUALITATIVE VARIABLES |

| Qualitative Variables | | | |
|---|---|---|---|
| **Type of Variable** | **Definition** | **Examples of Data** | **Common Statistical Tests and Summaries** |
| Nominal (also called *categorical* ) | The data are described by words or categories. They are not numerical and cannot be automatically ranked from high to low. | • Colors<br>• Gender<br>• Occupation<br>• Location | • Mode<br>• Chi-square<br>• Anova<br>• Paired t-test |
| Ordinal (also called *ranked*) | The data are described by words or categories. Although they are not numerical in the sense that the values can be added or subtracted, the categories can be ranked from high to low. | • Amount of pain on a scale of 1 (low) to 10 (high)<br>• Moh's scale of hardness for minerals<br>• IQ<br>• Degree of like or dislike | • Median<br>• Mode<br>• Kruskal-Wallis<br>• Ordinal logisitic regression |